Standards for Irrigation and Foliar Contact Water

Produce and specialty-niche crops often are irrigated with ground water, surface water, and reclaimed or recycled water throughout the US. It is estimated that 18% of worldwide cropland is irrigated, producing 40% of all food. Between 2003 and 2008 the total irrigated acreage for U.S. farms and ranches increased almost 5% (NASS, 2009). In the recent Census of Agriculture, NASS reports almost 10 million acres of commercial farm fruits, nuts, and vegetables in the U.S. and over 7 million of these under some form of irrigation management.

As greater attention has been directed to the rising evidence and role for fresh produce in illness and outbreaks, pressure for increasingly specific and prescriptive food safety programs and associated standards has come from several directions. The prevailing approach has been to adopt science-based standards anchored to a recognized authority or established metric for risk reduction wherever possible. One of the most contentious of these emerging metrics has been the debate over irrigation water standards.

Irrigation Processes and Produce Contamination

Irrigation water and any foliar applied water, with intimate contact to the developing or mature edible portions of fresh produce, is one of the most probable sources of fresh produce contamination with pathogens of concern for human health. Irrigation water sources include wells, ponds, rivers, streams, municipal water sources, and reclaimed (treated wastewater) water. The complexity of on-farm irrigation water management may easily be appreciated by even a cursory list of the many ways irrigation water can be applied including overhead, furrow, flood, seep ditches, surface drip, and subsurface drip to name a few Likelihood of contamination is also dependent on the commodity being grown.

For most individuals, the term irrigation water is fairly self-evident. Foliar contact water in the context of preharvest (crop production) management applies to many less familiar practices including but not limited to the following items;

- Pesticides
- Nutrients
- Growth regulators
- Manure teas and compost teas
- Thinning aids
- Harvest aids
- Frost control
- Anti-transpirants
- Dust control
- Microenvironment management

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State of the Science: Implications of Changes to Management Practices

While there is concern for all sources of water designated for preharvest use, relative to food safety, in the major production regions of the U.S., surface water is generally viewed as more susceptible to fecal contamination than is ground water.

Irrigation water, which can be a source of pathogenic microorganisms, can ultimately contaminate agricultural products. A variety of fecal contaminants and pathogens such as *E. coli*, *Salmonella* spp., *Listeria* spp., *Shigella* spp., *Crytosporidium*, and enteric viruses have been isolated from irrigation water and associated sediments.

Irrigation with surface water is expected to pose greater risk to human health than irrigation with water from deep aquifers drawn from properly constructed and protected wells. The potential for ground water contamination from surface events, such as flooding or storm-related run-off from areas of concentrated manure accumulation, manure lagoons, or sewage treatment facilities, is well characterized.

Though not conclusively linked, the California Department of Health Services (CDHS) and U.S. Food and Drug Administration (FDA) targeted irrigation water in a single spinach field as a possible source of the 2006 E. coli outbreak in spinach. This pivotal outbreak, for which economic consequences were estimated to be over $200 million contributed directly to demand for safety standards in the production of fresh produce.

While irrigation water has been studied extensively these studies were concerned primarily with chemical rather than microbiological water-quality parameters. As a result, the knowledge gap regarding sanitary quality of irrigation waters is nationwide.

- The lack of uniform standards that have accepted and compelling predictive value, relative to cost, in relation to known pathogen risk is a key barrier to implementing testing programs among growers. In the absence of a publicly available database from extensive testing, producers require an authoritative basis against which to preliminarily set the microbiological safety of irrigation water.
- Many reports have demonstrated that E. coli can survive and multiply in irrigation water, wastewater, subtropical sediments, and mineral water. Persistence of indicator organisms (IO) in the absence of detectable levels of pathogens and secondary growth, strongly suggest that the use of current IO is compromised and renders decision-making or rule-making based on presence/absence or numerical thresholds borrowed from stringent recreational water quality standards an unnecessarily self-penalizing practice.

Other areas of concern:

- Current water quality standards poorly define the relation between indicators, pathogens and risk of consuming produce.
- Fresh produce growers need the tools and ability to differentiate high-risk irrigation water from low-risk irrigation water

Recreational water standards may be unsuited for application to irrigation water

Many regional GAP and CSG systems have relatively recently adopted Environmental Protection Agency (EPA) recreational water quality criteria for establishing action

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thresholds, in the absence of actual risk-based data developed specifically on irrigation water (CSFSGLLGSC 2006 updated 2009).

The science behind the recreational water criteria was intended to maintain a risk of gastrointestinal illness lower than 8 cases per 1,000 swimmers at freshwater beaches (US EPA 1973; Marr, 2001) based on exposure to point-source, untreated human wastewater discharge or spill. The EPA criteria were not intended to apply to risks associated with irrigation management of edible crops and do not take into account the kinetics of die-off during post-irrigation intervals and exposure to environmental stresses associated with crop production.

Recognizing the limitations of the current irrigation standards, the FDA's recently released Draft Commodity Specific Guidance documents for leafy greens, melons and tomatoes (FDA 2009) provides no specifics, critical limits, or metrics based on indicators or pathogen prevalence in a standardized sample volume of any size. Producers are held to self-determination of the broadly applicable position that water should be "of appropriate quality for its intended use, obtaining water from an appropriate source, or treating and testing water on a regular basis and as needed to ensure appropriate quality".

Key Issues and Challenges of Test Methods and Indicator Organisms

Effective guidelines for health protection should be practical and adaptable to fresh produce production. Commodity, crop management practices, climate and region, other agro-ecological factors, and other modifiers should be evaluated in setting microbiological limits.

- Despite best efforts and understandable limitations, current irrigation water quality criteria are among the most universally relevant but contentious and least satisfactory standards that have been adopted.
    - Generic (commensal) E. coli have been used as the IO of choice; however no clear and supportable standards have been available to establish microbial limits or criteria that define suitable versus unacceptable quality for the diverse sources and modes of application.
    - The adoption of meaningful and predictive standards or criteria, particularly for irrigation water quality, is significantly hampered by the apparent lack of correlation between indicator coliforms or generic E. coli levels and the detectable presence of pathogens such as EHEC. Micro and mesocosm studies have demonstrated the severe limitations of popular IO's, including commensal E. coli, in predicting pathogen presence or correlating to proportional survival following fecal contamination. Many reports have demonstrated that E. coli can survive and multiply in irrigation water, wastewater, subtropical sediments, and mineral water.

Foliar Water Source Issues

The expectation that foliar applications for crop management of fresh produce will use only potable sources is widely held and largely followed in the U.S. However, convenience and human nature sometimes dictates that water is drawn from the closest source to the point of application. Those sources create a number of challenges:

- The filling of spray tanks with water pumped or scooped into back-pack sprayers from uncharacterized surface water sources.

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- The growth of pathogens within the application equipment as water temperature rises, especially if excess material is held in the tank for hours or overnight or if spray tanks and lines are not cleaned out after use.
- Surface water sources that are tested periodically may have unsuspected sources of contamination in sediments that are picked up by improper placement of PTO or pump-driven siphons.

Contamination Potential Between Sampling Intervals

Irrigation water is mistakenly assumed to be a highly controllable farm input.

Human-impact on water safety such as dredging, construction, and removal of algae, aquatic weeds, bull-rushes, and bank vegetation all come into play.

Growers have identified inconsistencies in agency notification of such maintenance activities, especially of concern during in-season intervals, as compromising their Sanitary Survey assumptions for water source hazards in GAPs plans.

Any standard for sampling intervals must take into account key unique risk factors related to sediments as a reservoir for pathogen survival and their redistribution or de-stratification during turbulent flow or mechanical disturbances.

Conclusions

A single national standard for irrigation water quality applicable to all commodities, regions, and scales of production seems both unwise and unattainable without creating hardship to the fresh produce sector or allowing sporadic unacceptable levels of risk to consumers. Just as science-based criteria are required for recreational waters, science should be applied to formulate flexible and risk-based criteria for irrigation waters. Given that protection of public health by control of irrigation water quality is a necessary step for the fresh and fresh-cut fruit and vegetable industry to implement.

Effective control of irrigation-water quality will depend on the economics of control. Producers cannot make informed decisions, given the current state of information regarding irrigation water, about choice of commodities to grow, at what time and from what source to irrigate, and whether to sacrifice yield for safety by choosing not to irrigate with high-risk water.

Before rules are set, knowledge gaps in these areas must be met: 1) the sanitary quality of many irrigation water sources, 2) the relation between density of traditional fecal-indicator bacteria (such as E. coli) and the risk of encountering key food borne pathogens (such as E. coli O157:H7 and Salmonella), 3) the remediation costs for contaminated water prior to irrigation, 4) the willingness of producers to adopt and enforce variable irrigation water quality standards.

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